REPRINTED FROM

CIRCADIAN CLOCKS

PROCEEDINGS OF THE FELDAFING SUMMER SCHOOL

7–18 SEPTEMBER 1964

Sponsored by

the Scientific Affairs Division

North Atlantic Treaty Organization

Editor

JÜRGEN ASCHOFF

Max-Planck-Institut für Verhaltensphysiologie,
Erling - Andechs, Germany

CIRCADIAN VOCABULARY

A recommended terminology with definitions

J. ASCHOFF, K. KLOTTER and R. WEVER

1965

NORTH-HOLLAND PUBLISHING COMPANY—AMSTERDAM

CIRCADIAN VOCABULARY

A recommended terminology with definitions

J. ASCHOFF, K. KLOTTER and R. WEVER

I. oscillator.

oscillating systems:

1. active system:

capable of self-sustained oscillations (endogenous rhythms).

An active system can obtain the energy necessary for maintaining the oscillation from a constant source of energy.

2a. passive system:

capable only of forced (exogenous rhythms) or free damped oscillations.

A passive system cannot obtain the energy necessary for maintaining the oscillation from a constant source of energy.

b. extremely passive system:

not capable of free damped oscillations.

The classification given above refers to internal features of the oscillating systems; on the other hand, the following classification refers to external conditions.

1. autonomous system:

not under the influence of a periodic source of energy, i.e. self-sustained and free damped oscillations.

2. non-autonomous system:

under the influence of a periodic source of energy, i.e. forced oscillations whether in active or passive systems.

Properties of oscillating systems:

active systems have one or several (multiple and submultiple) limited ranges of entrainment.

passive systems have an unlimited frequency range of forced oscillations. (c.f. range of entrainment)

II. oscillation.

period:

time after which a definite phase of the oscillation reoccurs.

frequency:

reciprocal of period.

(Note: in biological experiments it should be stated what phase has been used to determine the period.
The term period in its strict sense is only applicable if any selected phase leads to the same value for the period: if different phases give different values, a special explanation is necessary.)

circadian rhythm:

oscillation with a period of about 24 hours.

mean value:

arithmetic mean of all instantaneous values of the oscillating variable within one period.

amplitude:

difference between maximum (or minimum) value and mean value in a sinusoidal oscillation. In a looser sense this term often is applied to oscillations of a general shape also; in this case, the correct term positive (or negative)

extreme value

is preferable.

range of oscillation

difference between maximum and minimum value (in all cases).

phase:

instantaneous state of an oscillation within a period, represented by the value of the variable and all its time derivatives.

phase angle:

value of the abscissa corresponding to a point of the curve (phase) given either in radians, in degrees or in other fractions of the whole period. It can be given in units of time, if the length of the period is stated.

phase angle difference:

c.f. III.

phase shift:

a single displacement of an oscillation along the time-axis.

advancing phase shift:

one or a few periods shortened; sign: +.

delaying phase shift:

one or a few periods lengthened; sign: -.

(Note: in order to be in accordance with mathematical and physical notations, the signs for advancing and for delaying phase shifts have been exchanged as against the previous usage in biology.)

III. synchronization:

state in which two or more oscillations have the same frequency due to mutual or unilateral influences.

entrainment:

coupling of a self-sustained oscillation to a Zeitgeber (forcing oscillation) with the result that. either both oscillations have the same frequency (synchronization). or that the frequencies are integral multiples (frequency-demultiplication): possible only within limited ranges of frequencies.

range of entrainment:

range of frequencies within which a self-sustained oscillation can be entrained with a Zeitgeber (a forcing oscillation).

forcing oscillation:

oscillation (e.g. periodic environmental factor) capable of synchronizing or entraining another oscillation.

Zeitgeber:

that forcing oscillation which entrains a biological rhythm.

(Since entrainment is confined to systems capable of self-sustained oscillations. the term Zeitgeber in its strictest sense can be used only if self-sustained oscillations have been shown to exist in the biological system; a looser usage of the term. of course. is scarcely avoidable.)

synchronizer:

synonymous with Zeitgeber.

entraining agent:

synonymous with Zeitgeber.

phase relation:

general term for the time-relation between two coupled oscillations.
More precisely described by

phase angle difference:

difference between two corresponding phase angles in two coupled oscillations. given either in degrees of angle or in time units.

(Note: in non-sinusoidal oscillations, especially in the case of a biological rhythm synchronized with a Zeitgeber. 'corresponding' phase angles have to be defined more or less arbitrarily.)

(phase. phase angle: c.f. II)

leading, lagging phase:

if the phase of an entrained biological rhythm appears earlier than the corresponding one of the Zeitgeber, the biological phase leads the Zeitgeber phase; the sign for the resulting phase angle difference is +. For a lagging phase (= biological phase later than that of the Zeitgeber) the sign is -.

IV. free running rhythms:

self-sustained oscillations under constant conditions.

free running (spontaneous) frequency:

free running (spontaneous) period:

frequency or period, respectively, of a self-sustained oscillation.

(Note: to use the term 'free running', a sufficient number of undamped oscillations should be demonstrated.)

response curve:

indicates, in biology, how the amount and the sign of a phase shift, induced by a single stimulus, depends on the phase in which the stimulus is applied.

(Note: it should be stated how the phase shifts have been measured, e.g. by using the first measurable phase after the stimulus or the final steady state.)

transients:

temporary oscillatory states between two steady states.

V. symbols:

τ	period of biological rhythm
T	period of Zeitgeber
α	activity time
ρ	rest time
φ	phase angle of biological oscillation
$\Delta\varphi$	amount of shift of φ
Φ	phase angle of Zeitgeber
$\Delta\Phi$	amount of shift of Φ
$\Delta\varphi = f(\varphi)$	response curve
$\Psi (= \Phi - \varphi)$	phase angle difference between Zeitgeber and biological oscillation
LD	light-dark cycle a light-dark cycle is composed of light time (L) and dark time (D); the term photoperiod is synonymous with light time.
L	light time c.f. light-dark cycle
D	dark time there exists a time-ratio between L and D and also an intensity-ratio. To describe this it is proposed to use:
LD $x_1{:}x_2$ $(y_1{:}y_2)$	light-dark cycle with x_1 = duration of light time x_2 = duration of dark time y_1 = intensity of illumination in L y_2 = intensity of illumination in D (duration given in hours, intensity given in lux)

	(the intensity of illumination of D in LD is not always unmeasurably low but only of a lower intensity than that of L.)
	e.g.:
LD 16:8 (100:0.1)	light-dark cycle composed of 16 hours light time with 100 lux and 8 hours dark time with 0.1 lux.
LL	continuous illumination it is proposed to describe the intensity of illumination in LL as follows:
LL (y)	continuous illumination with y = intensity of illumination (given in lux)
DD	constant unmeasurably low intensity of illumination ('total darkness'). If there is a measurable low constant illumination, the term should be LL (y). E.g.: LL (0.001).
c.t.	circadian time. A time scale covering one full circadian period. The zero point is defined arbitrarily.
Z.t.	Zeitgeber time. A time scale covering one full Zeitgeber period. The zero point is defined arbitrarily.